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THE ROLE OF NATIONAL GEOLOGICAL SURVEYS IN MINERAL RESOURCES DEVELOPMENT

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THE ROLE OF NATIONAL GEOLOGICAL SURVEYS IN MINERAL RESOURCES DEVELOPMENT*

by

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Introduction

1. Mineral deposits and oil fields are a consequence of their geological environment and their discovery is dependent upon the basic knowledge of a nation's geology. Likewise, damsites for hydroelectric power, quarries and gravel banks for road construction and underground water for farm and city use are resources whose development rests heavily on geological considerations. Thus a nation who would know its natural resources must first know its geology. During the past century, most of the countries in the world have found it advantageous to maintain a national geological survey whose responsibility is to gather, to sort, and to make available the cumulative knowledge of the nation's geology.

2. Other papers will discuss the development of mineral resources. It is pertinent here only to remind the reader that a potential stone quarry, mineral deposit, or oil field becomes a resource only in the measure that it is used in the development of a nation's economy. Undeveloped mineral resources, unlike money in the bank, earn no interest.

3. The broad considerations presented in this paper are based upon observations during the past two decades during which the U. S. Geological Survey has actively been engaged in giving technical assistance in geology to other countries under the auspices and with the financial support of the Agency for International Development and its preceding organizations of the Government of the United States. The paper is addressed to those legislative and administrative governmental officers who plan and who authorize governmental expenditures in natural resource development rather than to the professional geologist to whom most of this material will already be familiar.

The task

4. The task of a national geological survey, inherent in its title, is to study, in the broadest possible sense, the geology of the nation. Geology must be interpreted broadly to include not only the fundamental mapping of rock units by the field geologist but also to employ the supporting services of paleontology, petrology, geophysics, geochemistry, and many other specialized techniques that are discussed in other papers at this meeting.

5. The task begins with the preparation of adequate base maps, which, in some countries are prepared by the national geological survey and in others by some national mapping organization without geological responsibilities. Either system can be effective if there is close correlation in planning to assure the readiness

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of proper base maps at the time geological mapping is to begin.

6. The mapping scale chosen is generally a compromise arrived at after consideration of the total area to be mapped, the complexity of the geology and the availability of competent geologists to do the field work. There is always an understandable desire for as much geological detail as possible requiring larger map scales which must be balanced against the limiting factors of total area, scheduled time and available personnel.

7. Commonly, a compromise is reached in which the areas either known to be mineralized or holding the greatest promise of mineralization are mapped on a larger scale than that used for the other parts of the nation.

8. With the development of photogeology in recent years, the question frequently arises as to the relative merits of photogeology and conventional field methods. There is no doubt that in suitable terrane photogeologic methods permit a much faster coverage of large areas than can be done by other means. It must be borne in mind that photointerpretation is dependent upon considerable knowledge of the composition of the rocks, their succession and their topographic expression. Again, a compromise is generally advisable in which photo methods are used by a field geologist to extend and amplify what he can see from the ground. Photogeology can best be regarded as just another tool of the field man, rather than as a substitute for him.

9. Within recent years airborne geophysical surveys have been widely used. It must be kept in mind that such surveys involve no magic perception but only provide a means for measuring and recording certain physical differences in the rocks over which the plane flies, such as magnetic permeability, nuclear radiation or electromagnetic induction.

10. Differences in the magnetic field essentially are due to differences in the magnetite content of the rocks below. A large deposit, even deeply buried, of magnetic iron ore is readily recorded and differences between igneous rocks containing even small percentages of magnetite and some sedimentary rocks that do not contain magnetite are also recorded. Other differentiations such as the depth of sedimentary cover, as is used in petroleum exploration, are more subtle and difficult to interpret.

11. Radioactivity measurements are made with a recording scintillation counter carried in the plane. Under favorable conditions of little or no cover, deposits of radioactive minerals of uranium and thorium can be detected from the air. Airborne measurements can detect differences of radioactivity as small as 6 parts per million, which gives us a useful geological tool for differentiating rocks of unequal amounts of contained radioactive minerals.

12. Certain metallic minerals occurring at shallow depths can be detected by plane borne electromagnetic devices. Great care and considerable experience are required in the interpretation of the record. This method has been very successful in the Canadian Shield.

13. A combined magnetic and radioactivity airborne survey costs approximately seven U.S. dollars per linear kilometer. The maximum spacing of flight lines, for mineral investigation, is approximately one kilometer. Thus, the basic cost per thousand square kilometers is of the order of $6,000.

14. Electromagnetic induction methods require closer flight lines with a maximum interval of approximately one half kilometer. The basic cost of a combined electromagnetic induction, magnetic and radioactivity airborne survey is of the order of

$15,000 to $20,000 per thousand square kilometers.

15. These approximate costs apply to a survey of the general magnitude of 10,000 linear kilometers. To this must be added the costs of bringing the plane into the area and returning it to its home base. In areas of uncertain flying weather, a "stand by" charge is also made for the time the plane is grounded by bad weather. The above figures are intended only to be illustrative of the general magnitude of costs for airborne geophysical surveys in recent years.

16. Airborne geophysical surveying is expensive and, unless its planning is carefully based on considerable knowledge of the geology of the terrane to be flown, the money spent on the survey may be wasted. In planning such airborne geophysical surveys due consideration must be given both to the likelihood of new direct discoveries, such as a magnetite, uranium, or sulfide ore body, and to the probability of obtaining geophysical profiles that, while not leading to direct discovery of ore bodies, do give useful information about formational contacts and structural attitudes. The geological administrator who is considering undertaking an airborne geophysical survey must, in the light of his knowledge of the geology of the area to be investigated, weigh the probability of obtaining useful information against the cost of other possible field methods.

17. The backbone of any geological survey is its field geologists. The muscle and flesh are the specialists - paleontologists, petrographers and others whose specialized knowledge is necessary for the interpretation of the geological picture. Most field geologists have specialties. Thus a stratigrapher-paleontologist would study an area of sedimentary rocks while a petrographer would map a region of dominantly igneous rocks. Only the larger geological surveys of the industrialized nations can, expectably, have a full complement of all the specialists who can contribute to the understanding of all of the branches of geology. The smaller nations, necessarily dependent upon a smaller geological staff, must use great care in selecting and in training their geologists in the fields of specialization that locally are most important.

18. In general, a geologist's usefulness bears a direct relationship to his knowledge of the geology in the area where he works. As such knowledge is cumulative, each season in the field increases his value to the nation. This growth in usefulness is a factor worthy of serious consideration by a nation's geological administrators. Not only should experienced men be encouraged to continue their work, but provision must be made for a steady supply of new and younger men, chosen for their basic education, to grow into the experienced geologists of the future.

19. The problems of geological education are discussed in other papers at this meeting. It is pertinent here, however, to point out that many of the smaller nations, for some years in the future, will be dependent upon foreign education for their geologists. Most of the industrial nations are prepared to share their educational facilities and to undertake the training of the young geologists of the emerging countries. In the last two decades, the United States Geological Survey has welcomed 569 young geologists from 66 different countries who have worked in our field parties and our laboratories and who have attended our universities. The problems of education and training deserve serious and continued consideration by the geological administrators of the younger nations.

20. Geological information should be made available to possible users at the earliest possible time. The established geological surveys publish maps and reports in various formats. Provision should be made for strict internal scientific criticism of these maps and reports prior to publication so that the information they contain is both accurate and well expressed. Good administrative judgment is always needed to weigh timeliness against perfection, but timeliness

should never be an excuse for poor workmanship, either in the field or in publication format. It is interesting to note that, in recent years, members of some of the younger geological surveys have shown an increasing interest in the techniques of copy preparation, map drafting for color separation and other details of the publication process.

21. Briefly, it is the task of the geological administrator to carefully define the goals of his survey, to establish the work priorities, to choose scales and mapping methods, to encourage his experienced scientific personnel and to intelligently recruit the personnel of the future and, finally, to present the results as promptly and as lucidly as possible.

Some difficulties in recent years

22. Within recent years the geological surveys of some countries have suffered serious loss of scientific personnel either as a consequence of currency inflation or through repatriation.

23. The geological surveys of some of the semi-industrialized nations have suffered from lack of adequate financial support and continuing loss of geologists and other scientists to higher-salaried industrial positions. These losses have been particularly acute in countries that have experienced rapid currency inflation that has not been compensated by adequate and timely salary increases or cost of living allowances. Generally, the basic need for resources development has been disregarded in the press of political and social problems that arose from the inflation. The greatest tragedy in such cases is the interruption of recruitment of the young geologists upon whose work future development should rest.

24. Most of the countries that have attained independence during the past two decades inherited some form of a national geological survey, but, in some countries, the loss of inherited scientific personnel has outstripped their replacement by adequately trained nationals. When one considers that four years of university work is a bare minimum training for a young geologist, it may be several years before some countries can overcome their losses in trained personnel.

Foreign geological assistance

25. In recent years several of the industrialized countries, some of the specialized agencies of the United Nations, and the Colombo Plan have given technical assistance in geology. This assistance has taken several forms ranging from short time consultants in specialized fields to broad technical aid extending over a decade. Recently, the Special Fund of the United Nations has financed geological and geophysical surveys and drilling campaigns in a number of countries.

26. Technical assistance in geology by the United States Government began in 1940 and has continued to the present time during which 291 geologists, hydrologists and other earth scientists of the U. S. Geological Survey have executed 423 different assignments in cooperation with geologists in 57 different countries under the auspices and with the financial support of the Agency for International Development and its preceding organizations of the Government of the United States. In this time over 500 young geologists from more than 60 countries have received training in the U. S. Geological Survey as a part of the technical assistance program.

27. Our own experience in working abroad has been a happy one, unmarred by any serious incidents of misunderstanding with our fellow geologists. The projects have been truly cooperative for our geologists have worked with the geologists of the host country in the field and their reports have been published under the joint authorship of the two nationals. As a result of the last 20 years of our

foreign geological cooperation, more than five hundred geological reports and other scientific papers have been published.

28. In many countries there is still need for foreign technical assistance in geology and this need will not be fully satisfied within the next decade. It is well, however, to keep firmly in mind that the ultimate objective of such assistance is to see the host country attain scientific self-sufficiency. Thus, the technical aid programs of both the industrialized nations and of the international bodies like the United Nations and the Colombo Plan must be considered as temporary measures designed to aid the emerging nations in attaining their own scientific stature and technical self reliance.

Continuity of effort

29. Past experience has shown that the geological inventory is never finished. Geological Surveys should be established as permanent institutions, adequately staffed, to meet the continuing geological needs of the country. Many past failures have resulted from a narrower objective. Most of the industrialized nations have long-established geological surveys and their present task is to improve and refine the great store of geological information that they have gathered through the years of their existence. This involves remapping on larger scales as the need for more detailed information arises. It involves the application of new techniques and the reinterpretation of old data from newer scientific viewpoints. It will involve the training of new generations of earth scientists in the scientific arts that the future will surely bring. All these are thoughts that the skillful geological administrator and the enlightened legislator must ever keep in mind.

1657 E - Nov. 1962 - 1, 600